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FINAL TECHNICAL REPORT

for

DEFINITION PHASE OF A MULTIBAND IMAGING PHOTOMETER (MIPS) FOR THE SPACE INFRARED TELESCOPE FACILITY (SIRTF)

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Final Report
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Grant NAG 2-320 supported a variety of activities in far infrared detector development that lay the foundation for the initial definition of the Multiband Imaging Photometer for SIRTF (MIPS). The primary goal of the MIPS team under this grant was to evaluate the feasibility of producing the very high sensitivity detectors and readouts that are required to reach the background limit with SIRTF. Because of the wide wavelength coverage mandated for MIPS during this time, extending from 4 through 700μm, investigations included a very broad variety of detector types, ranging from InSb and HgCdTe photodiodes through bulk extrinsic photoconductors based on both silicon and germanium to bolometers.

Under the leadership of co-Investigator Frank Low, a high sensivity integrating amplifier was developed based on junction field effect transistors (JFETs). Extensive investigations were conducted of the transistor types that gave the best performance in this operating mode, along with optimization of the temperature and electronic parameters for the amplifiers. A circuit that provides a balanced operating condition with output voltage near ground was demonstrated. These amplifiers have become the standard readout for subsequent laboratory testing of both photodiodes and photoconductors in the MIPS program.

Extensive evaluations were conducted of photodiodes furnished by Rockwell Science Center (HgCdTe) and Cincinnatti Electronics (InSb). This work was reported back to the manufacturers and in the case of HgCdTe in a paper presented at the Third Infrared Detector Technology Workshop. It was found that the quantum efficiencies of both diode types remained at a usefully high value at operating temperatures down to 6K (the lowest at which testing was conducted). The best detectors of both types achieved dark currents within a factor of 10 of the SIRTF background limit for wideband photometry. Therefore, a modest further development of either detector type would have promise for SIRTF applications. After this work was completed, the requirement for MIPS to operate at the wavelengths covered by these detectors was dropped.

Extrinsic silicon detectors were evaluated for use near 20μm. We looked at the performance of Si:B, Si:P (furnished by the Short Wavelength Spectrometer team for ISO), and Si:Sb (material from the IRAS program). Si:B had not been evaluated

extensively as an infrared detector, to the best of our knowledge. It showed substantial promise, particularly because of its very low dark current. Other aspects of these three detector types -- spectral response, responsivity, quantum efficiency, etc. -- were generally similar and at useful levels for SIRTF applications. After this work was completed, the requirement for MIPS to operate at the wavelengths covered by these detectors was dropped.

An initial screening of the materials available from the stocks grown by co-Investigator Eugene Haller was carried out under co-Investigator Erick Young. Substantial performance variations were found among diferent boules of both Ge:Be and Ge:Ga. Further assessment and development of arrays from these materials was carried out under the MIPS contract NAS2-12578.

Co-Investigator Paul Richards carried out a parametric study of the adiabatic demagnetization refrigerator (ADR) that showed the tradeoff between size of magnetic coil and hold time and allowed design of a device with optimum length to diameter for high efficiency. In addition, a computer program was found that allows design of magnetic shields such as are required for the ADR, and a shield was designed. These efforts became the foundation for the construction of an ADR under MIPS contract NAS2-12578 that demonstrates solutions to flight qualification of this type of device. Richards also conducted a tradeoff study between the ADR and alternate refrigerator types, including a closed cycle helium 3 refrigerator (the most commonly used alternative). This study showed that a properly optimized and fully developed ADR was the appropriate choice for applications such as MIPS, both because of the potential for improved bolometer performance at the low operating temperature of 100mK and because it could be developed to dissipate less heat at cryogenic temperatures.